

Sec 3 : ~~Control~~ Control

Quiz

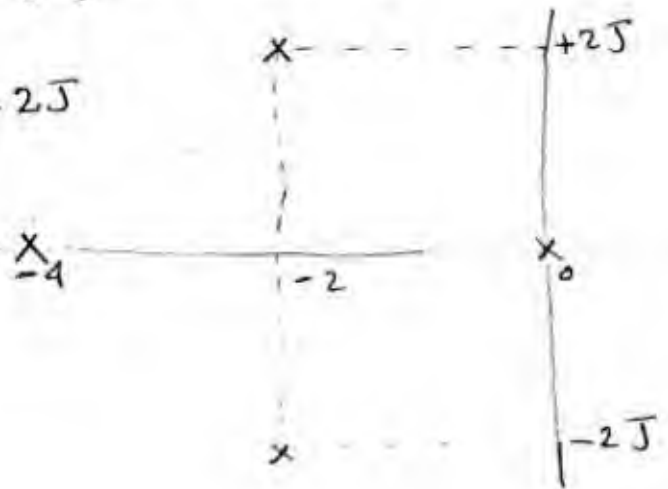
$$GH(s) = \frac{K}{s(s+4)(s^2+4s+8)}$$

Poles $\rightarrow 0, -4, -2-2j, -2+2j$

Zero $\rightarrow \phi$

Real Part

$0 \rightarrow -4$



Asymptotes

number $s \rightarrow 4 - 0 = 4$

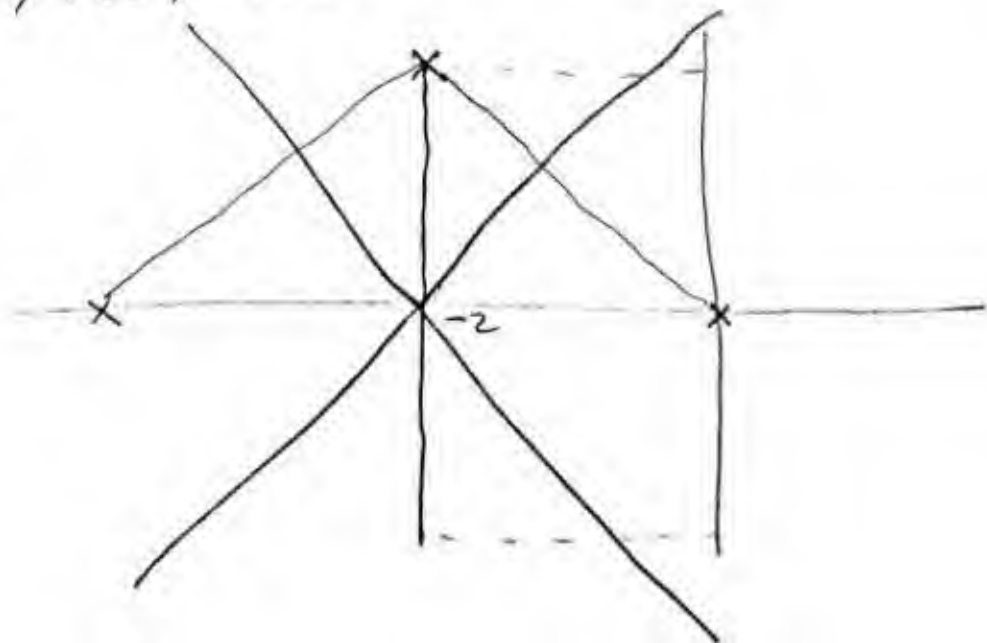
$$\sigma_A = \frac{(-4 + 0 - 2 - 2j - 2 + 2j) - 0}{4 - 0} = -2$$

$$\theta = 45^\circ, -45^\circ, 135^\circ, -135^\circ$$

$$\phi = 180^\circ - \phi_p - \phi_z$$

$$= 180^\circ - (90^\circ + \tan^{-1}(1))$$

$$+ 135^\circ) \text{ etc}$$



* For the system has O.L.T.F = $GH(s)$
Prove that $K = \frac{\pi P_i}{\pi Z_i}$

Sol

$$\text{O.L.T.F} = GH(s)$$

$$\text{C.L.T.F} = \frac{K GH(s)}{1 + K GH(s)}$$

$$\text{clc eqn} = 1 + GH(s) = 0$$

$$K GH(s) = -1 = 1 \angle 180^\circ$$

$GH(s)$: Function in complex variable

$$s = \sigma + j\omega$$

$$\|GH(s)\| = 1$$

$$\angle K GH(s) = 180^\circ$$

$$K = \frac{1}{\|GH(s)\|}$$

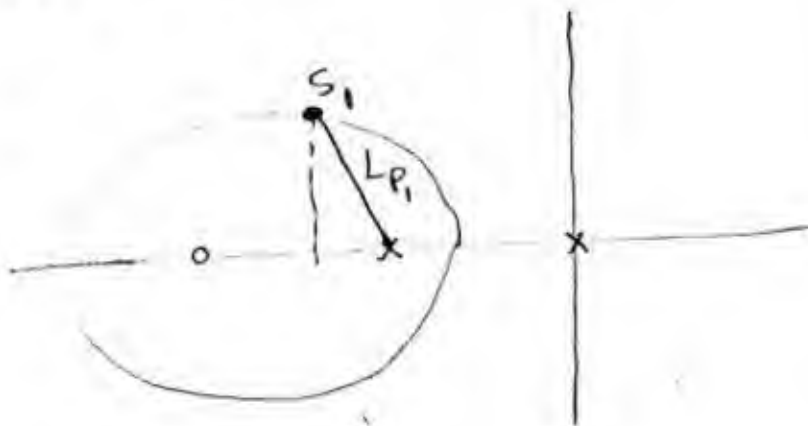
$$GH(s) = \frac{(s+z)(s+z_2)\dots}{(s+p_1)(s+p_2)\dots}$$

$$\|GH(s)\|_s = \frac{|s+z_1||s+z_2|\dots}{|s+p_1||s+p_2|\dots} \bigg|_{s=s_1}$$

$$s_1 = \sigma_1 + j\omega_1$$

hint $a + jb$

$$\Rightarrow \sqrt{a^2 + b^2}$$



$$\|GH(s)\|_s = \frac{[a + j\omega + z_1] \dots}{[a + j\omega + p_1] \dots}$$

$$z_1 = \sigma_{z_1} + j\omega_{z_1}$$

$$\|GH(s)\|_s = \frac{\left[\sqrt{\text{Re}_{z_1}^2 + \text{Im}_{z_1}^2} \right] \dots}{\left[\sqrt{\text{Re}_{p_1}^2 + \text{Im}_{p_1}^2} \right] \dots}$$

$$= \frac{L_{z_1} \cdot L_{z_2} \dots}{L_{p_1} \cdot L_{p_2} \dots}$$

where

$L_{z_1} \rightarrow$ length of line between open loop zero and considered closed loop Pole(s_1)

$$\sqrt{2}$$

$$\therefore GH(s) = \frac{\pi L z_i}{\pi L p_i}$$

$$\therefore K = \frac{\pi L p_i}{\pi L z_i}$$

* Departure Angle From Complex Poles

$$\theta_d \pm 180 - \phi_p + \phi_z$$

* Arrival Angle to Complex Poles

$$\theta_A \pm 180 - \phi_z + \phi_p$$

تصحيح خطأ في المثال من السكتة الأولى.

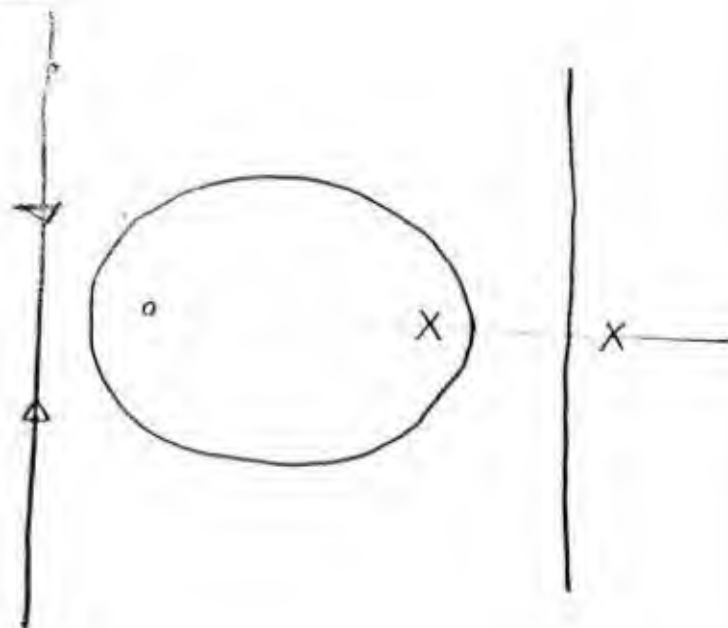
$$GH(s) = \frac{K(s+2)(s+4)}{s(s+1)}$$

الخط 3 و 5
(breaking point) II

Breaking out \checkmark

Breaking in $\times \times \leftarrow$ الخط

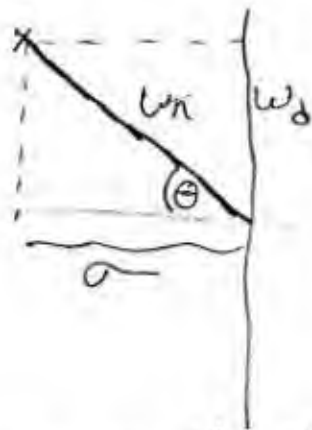
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Correction

Root locus Breaking in mores (between zero) little to right not the left

C.L. Poles



$$\omega_d = \omega_n \sqrt{1 - \zeta}$$

$$a = \zeta \omega_n$$

$$\sqrt{\omega_d^2 + a^2} = \omega_n$$

$$\Theta = \cos^{-1} \zeta$$

→ System speed depends on a .

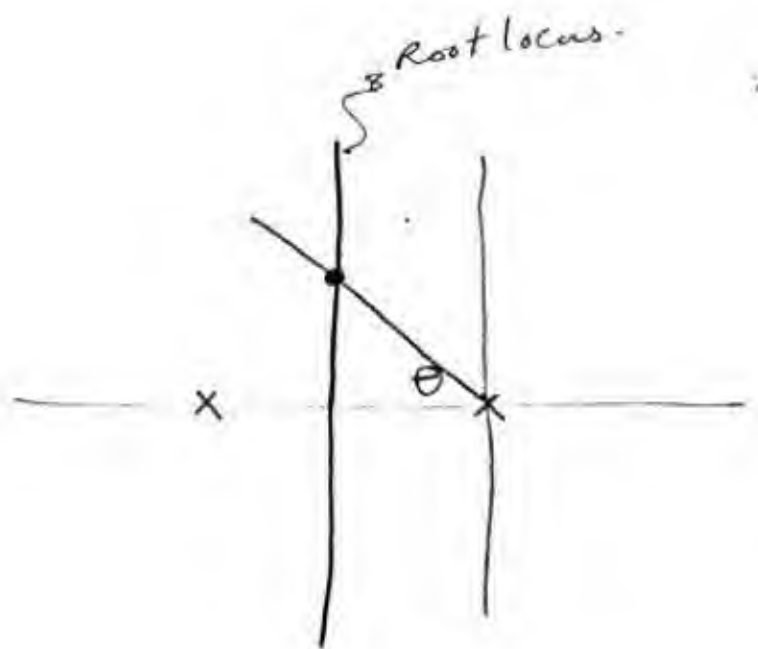
time Constant

τ time for system to reach 63% of the response

$$\tau \approx \frac{1}{a}$$

settling time $t_s \approx 4\tau = \frac{4}{a}$

Root locus



$$\text{num} = [1 \quad 6 \quad 16];$$

$$\text{den} = [1 \quad 4 \quad 8 \quad 0];$$

$$G = \text{tf}(\text{num}, \text{den});$$

$$\text{rlocus}(G)$$

Sisotool